Science
Module 6

Physical Science: Structure of Matter

Module Goal

The goal of this module is to provide information that will help educators increase their knowledge of grade-appropriate science concepts, knowledge, and skills to support effective planning or modification of their existing science instructional units for students with significant cognitive disabilities. The module includes important concepts, knowledge, and skills for the following instruction:

- Energy (elementary) – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system: light reflection, absorption, or refraction.
- Matter (elementary) – The composition and structure of matter is known, and it behaves according to principles that are generally understood: physical properties of matter and factors that influence physical change in matter.
- Matter (middle) – The composition and structure of matter is known, and it behaves according to principles that are generally understood: chemical reactions, visible properties of change, conservation of mass, atoms, and particle motion in states of matter.

Module Objectives

The content module supports educators' planning and implementation of instructional units in science by:

- Developing an understanding of the concepts and vocabulary that interconnect with information in the module units.
- Learning instructional strategies that support teaching students the concepts, knowledge, and skills related to the module units.
- Discovering ways to transfer and generalize the content, knowledge, and skills to future school, community, and work environments.

The module provides an overview of the science concepts, content, and vocabulary related to Physical Science: Structure of Matter and provides suggested teaching strategies and ways to support transference and generalization of the concepts, knowledge, and skills. The module does not include lesson plans and is not a comprehensive instructional unit. Rather, the module provides information for educators to use when developing instructional units and lesson plans.

The module organizes the information using the following sections:

I. Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts;
II. Scientific Inquiry and Engineering Design;
III. Connecting Concepts;
IV. Vocabulary and Background Knowledge information, including ideas to teach vocabulary;
V. Overview of Units' Content;
VI. Universal Design for Learning (UDL) Suggestions;
VII. Transference and Generalization of Concepts, Knowledge, and Skills; and
VIII. Tactile Maps and Graphics.

Section I

Science Academic Standards and Related Alternate Assessment Targets and Underlying Concepts

It is important to know the expectations for each unit when planning for instruction. The first step in the planning process is to become familiar with the identified academic standards and related Alternate Assessment Targets (AATs) and Underlying Concepts (UCs) covered in the module. The AATs are specific statements of knowledge and skills linked to the grade-specific science academic standards. The UCs are basic key ideas or concepts linked to specific AATs. UCs are a basis for developing a more complex understanding of the knowledge and skills represented in the AAT and should not be taught in isolation. It is important to provide instruction on the AAT along with the UC in order to move toward acquisition of the same concepts, knowledge, and skills.

Table 1 includes the academic standards and related AATs and UCs for Physical Science: Structure of Matter. While only the academic standards targeted for the Tennessee Comprehensive Assessment Program/Alternate (TCAP/Alt) are included, instruction on additional standards will aid in student understanding. Standards that are not included still represent important content for students to master. Therefore, the AATs and UCs included in the table do not cover all of the concepts that can be taught to support progress and understanding aligned to the standards.

Table 1. Science Academic Standards and Related AATs and UCs [1]

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
Energy – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system.		
0407.10.2 Determine which surfaces reflect, refract, or absorb light.	Identify types of surfaces that reflect light, absorb light, or allow light to pass through.	Identify light energy as the energy that can be seen and used to see matter.
Matter – The composition and structure of matter is known, and it behaves according to principles that are generally understood.		
0507.9.1 Distinguish between physical and chemical properties.	Classify materials as solid, liquid or gas by physical properties.	Identify the properties shared by a group of objects.
0507.9.3 Describe factors that influence the rate at which different types of material freeze, melt, or evaporate.	Identify factors that influence the rate at which water will freeze, melt, or evaporate.	Recognize that water may undergo a change in state from liquid to solid or from solid to liquid.
0807.9.1 Recognize that all matter consists of atoms.	Use a model to demonstrate that all matter consists of atoms (e.g., the observation of the inflation and shape of a balloon).	Recognize that all matter can be broken down into smaller and smaller pieces until they are too small to be seen by our eyes.
0807.9.2 Identify the common outcome of all chemical changes.	Refer to data on the properties (e.g., color, texture, odor) of substances before and after chemical changes	Identify examples of change (e.g. state of matter, color, temperature, and odor).

Academic Standards	Alternate Assessment Targets (AAT)	Underlying Concepts (UC)
	have occurred (e.g., burning sugar or burning steel wool, rust) to answer questions.	
0807.9.6 Compare the particle arrangement and type of particle motion associated with different states of matter.	Compare the visible property of solids (does not change shape) and liquids (take the shape of any container) to its type of particle motion.	Identify matter in three different states: solid, liquid and gas.
0807.9.10 Identify the reactants and products of a chemical reaction.	Identify evidence that proves a chemical reaction has taken place (e.g., something new is visibly produced, gas is created, heat is given off or taken in).	Understand that a chemical reaction leads to a chemical change.
0807.9.11 Recognize that in a chemical reaction the mass of the reactants is equal to the mass of the products (Law of Conservation of Mass).	Identify a chemical reaction in which the mass of the reactants is shown to be equal to the mass of the products.	Understand the total mass of a mixture is equal to the sum of the parts.

[1] Instruction is not intended to be limited to the concepts, knowledge, and skills represented by the AATs and UCs listed in Table 1.

Section II

Scientific Inquiry and Engineering Design

It is important for students with significant cognitive disabilities to have the opportunity to explore the world around them and learn to problem solve during science instruction. This approach to science instruction does not involve rote memorization of facts, rather it involves scientific inquiry. A Framework for K-12 Science Education (2012) unpacks scientific inquiry, providing eight practices for learning science and engineering in grades K – 12. These practices provide students an opportunity to learn science in a meaningful manner. Students should combine the science and engineering practices as appropriate to conduct scientific investigations instead of using a practice in isolation or sequentially moving through each practice. Support should be provided as necessary for students with significant cognitive disabilities to actively use the practices. See Section VI. Universal Design for Learning Suggestions for support ideas. Following are the eight science and engineering practices (National Research Council, 2012) with added examples.

- Asking questions (for science) and defining problems (for engineering).
  Examples: How does the color of clothing affect light reflection and absorption? Why do dark colored materials feel hotter when they have been in the sun? Which color holds heat longest? How will vinegar and baking soda react when mixed together? What evidence is needed to demonstrate which changes caused by heating or cooling are reversible from those that are not?

- Developing and using models.
  Examples: Use a pen light and a variety of objects to determine which objects reflect light, absorb light, or allow light to pass through. To build understanding of matter at the particle level, evaporate salt water, dissolve sugar in water, and add air to expand a balloon.
- Planning and carrying out investigations.
  Examples: Conduct an investigation to see what change occurs when mixing glue, water, and borax together. Conduct an investigation to determine the rate of different volumes of water in identical containers freezing. Determine which surfaces either reflect, refract, or absorb light.
- Analyzing and interpreting data.
  Examples: Analyze data on properties before and after a chemical change. Analyze the data showing the mass of the reactants and the mass of the product created during a chemical change to determine if the mass is conserved or lost.
- Using mathematics and computational thinking.
  Examples: Measure the initial and final masses of ice blocks placed under different conditions, and determine which factor caused the ice to melt the fastest. Measure the change in temperature when a chemical reaction has occurred (e.g., vinegar as it reacts to baking soda).
- Constructing explanations (for science) and designing solutions (for engineering).
  Examples: Explain why the temperature of a substance cools more quickly in a glass than in a Styrofoam cup. Explain how a chemical reaction activates a heat or cold pack.
- Engaging in argument from evidence.
  Examples: Use reasoning to connect the relevant and appropriate evidence and construct an argument that includes the idea that white clothing is cooler to wear in the summer than black clothing. Present an argument based on using the mass of the individual reactants prior to the reaction and the mass of the final product as evidence for the argument that mass is conserved during chemical reactions. Organize information about a variety of materials to categorize them as translucent, transparent, or opaque.
- Obtaining, evaluating, and communicating information.
  Examples: Communicate the idea that while matter undergoing a physical change looks different, it is still the same (e.g., ice is still water). Express the understanding that a chemical change produces a new substance.

Science Practices Resources

This site categorizes inquiry into three types: structured inquiry, guided inquiry, and open inquiry. Each type provides a wide range of example lessons grouped by elementary and middle school.
http://www.justsciencenow.com/inquiry/

The Inquiry section of the document on this site has a chart (page 3) providing variations on student roles in inquiry. http://www.inquiryinaction.org/pdf/InquiryinAction.pdf

A variety of sites that provide information on experiments, models, and simulations:

- Perkins School for the Blind has activities and a lesson plan to teach about light and its properties (e.g., reflection, absorption, refraction)
  - http://www.perkinselearning.org/scout/questions/concept-light-and-its-reflection
  - http://www.perkinselearning.org/accessible-science/light-energy

- This site provides an animated model of states of matter. http://www.abpischools.org.uk/page/modules/solids-liquids-gases/slg2.cfm?coSiteNavigation_allTopic=1
- This site provides hands-on activities regarding chemical reactions. https://owlcation.com/stem/hands-on-experiments-to-learn-about-chemistry)
- This site has an interactive model showing changes in states of matter given changes in temperature. http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_state_fs.shtml
- Glencoe provides a virtual lab to observe physical changes and record online data. http://www.glencoe.com/sites/common_assets/science/virtual_labs/E03/E03.html
- This site has a variety of experiments regarding chemical reactions. http://reekoscience.com/category/science-experiments/chemical-reactions

Section III

Connecting Concepts

Grade-level science content includes Connecting Concepts, which are concepts that connect information between different science strands and grade levels. The Connecting Concepts are intended to work together with the science inquiry and engineering practices, in addition to core content, to enable students to reason with evidence, make sense of phenomena, and design solutions to problems. Helping students make connections between these types of concepts and new content information supports comprehension of the concepts, knowledge, and skills as well as transference and generalization (see Section VII for more information). Connecting Concepts that are specific to this module connect to content across the units within the module as well as across modules.

A Connecting Concept is a common link between multiple standards and units of study. The Connecting Concepts, by being revisited and linked to multiple units of study, become a strong foundation of understanding and support the students in learning new concepts. Physical science focuses on physical and chemical principles that can be observed and applied to new systems and processes. For example, understanding that patterns can be used to determine similarities and differences is a Connecting Concept that applies to determining living vs. nonliving, differences and similarities of inherited traits, potential vs. kinetic energy, and physical properties of states of matter. Some Connecting Concepts may apply across multiple content areas and instructional emphases (e.g., mathematical patterns).

This science module, Physical Science: Structure of Matter, addresses the observable properties as a way to identify particular materials, the fact that matter is composed of atoms and molecules as a way to explain the properties of substances, the diversity of materials, states of matter, and conservation of matter.

Teaching Connecting Concepts

The following strategies pulled from the principles of UDL (CAST, 2011) are ways in which to teach Connecting Concepts to help students understand the concepts and make connections between different curricular content. During instruction, highlight:

- patterns (e.g., Water will change states with an increase or decrease in the temperature.),
- critical features (e.g., A physical change does not change what the substance is and can be undone. A chemical change creates a new substance which cannot be undone. All atoms are capable of changing states if given the right amount of heat.),

- big ideas (e.g., Matter is composed of atoms.) and
- relationships (e.g., Show the relationship between the surface type and how light behaves.).

For example, when learning about factors that influence the rate at which water freezes, melts, or evaporates, point out the cause-and-effect relationships that may explain the change. In addition, build connections between familiar and new information (e.g., Use cooking to demonstrate rate of change and the states of matter.).

Following are **Connecting Concepts** for this Content Module, Physical Science: Structure of Matter.

Understand Patterns

- Patterns can be used to determine similarities and differences.
- Observed similarities and differences can be used to sort and classify natural objects and designed products.
- Patterns in rates of change and cycles can be used to make predictions.
- Patterns can be observed and used as evidence.
- Patterns can be used to identify cause-and-effect relationships (e.g., The products of common chemical reactions can be predicted.).

Cause and Effect

- Some phenomena may have more than one cause.
- Cause-and-effect relationships may explain change (e.g., The arrangement of atoms and the state of matter have a direct correlation (solid molecules are packed tightly, etc.).

Scale, proportion, and quantity

- Natural objects and observable phenomena exist from the very small to the immensely large.
- Standard units can be used to measure and describe physical quantities such as weight/mass, time, temperature, and volume (e.g., correct units of measurement for a gas, liquid, and solid).
- Models using scale can be used to study systems that are too large or too small.

Energy and Matter

- Objects may break into smaller pieces, can be put back together, and may change shape.
- Matter is made of particles and energy that can be transferred in various ways and between objects (e.g., characteristics of light energy; energy transferred through particles).
- Energy drives the motion and/or cycling of matter.

Stability and Change

- Some things stay the same while some things change (e.g., The states of matter can be described according to their mass, volume, density, shape, and particle arrangement.).
- Things may change slowly or rapidly.
- Matter is conserved because atoms are conserved in physical and chemical processes (e.g., Balanced chemical equations show the Law of Conservation of Mass.).

Connecting Concept Resources:

Grant Wiggins talks about "big ideas" in this article.
http://www.authenticeducation.org/ae_bigideas/article.lasso?artid=99

A Framework for K-12 Science Education, Appendix G explains the crosscutting concepts and how the concepts help students deepen their understanding of the information.
http://www.nextgenscience.org/sites/default/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

TeacherVision provides ten science graphic organizers that are free and printable.
https://www.teachervision.com/graphic-organizers/science/52539.html

Section IV

Vocabulary and Background Knowledge

Vocabulary is critical to building an understanding of science concepts, knowledge, and skills. The vocabulary words that students gain through experiences provide ways for students to comprehend new information (Sprenger, 2013). Students can better understand new vocabulary when they have some background knowledge to which they can make connections. In addition, learning new vocabulary increases students' background knowledge. Therefore, it is important to teach vocabulary purposely when introducing new concepts, knowledge, or skills (e.g., chemical reactions) and in the context of the specific content (e.g., Teach the terms "properties," "reactants," "product," and "mixture" in the context of teaching and demonstrating chemical reactions.).

This module includes two types of vocabulary words, both equally important to teach. The first type, **general vocabulary words,** labels groups of words that generalize to a variety of animals, plants, organisms, systems, processes, or phenomenas. For example, understanding the meaning of the word "energy" helps students to understand light reflection and absorption, chemical reaction, etc. The second type, **specific content words,** represents groups of words that are associated with an organism, system, process, or phenomena. Specific content words (e.g., states of matter) connect to related general words (e.g., solid, liquid, and gas) to help students understand water freezing and evaporating. Providing exposure and instruction on general words provides background knowledge when introducing corresponding or related specific words.

Key Vocabulary for Instructional Units

Table 2 and Table 3 contain lists of key general vocabulary words and specific content words that are important to the units in this module. The vocabulary words span across grades three through eight, therefore, a teacher should refer to the TN science standards for grade specific words. Teach general vocabulary words to the student using a student-friendly description of the word meaning (e.g., texture is how things feel when they are smooth, rough, fuzzy, etc.) and an example of the word (e.g., The texture of sand paper is rough.). Teach the specific content vocabulary using a student-friendly description of the word meaning (e.g., States of matter are solid, liquid, or gas.) and a possible connection to a general vocabulary word (e.g., Ice is the solid state of water).

Do not teach memorization of vocabulary words; instead, place emphasis on understanding the word as a result of observation, investigation, viewing a model, etc. For example, a student should identify a physical property rather than defining the term.

Table 2. General Vocabulary Words

General Vocabulary – words that generalize to different animals, plants, organisms, and activities. Describe the word and provide examples (e.g., Reflection is when the light comes back to you. *Example: When you aim a flashlight on shiny metal the light bounces back to you.*)		
• absorb	• mass	• reflect
• atom	• matter	• refract
• color	• melt	• solid
• energy	• mixture	• substance
• evaporate	• motion	• surface
• freeze	• odor	• temperature
• gas	• particles	• texture
• heat	• pieces	• water
• light	• properties	• wind
• liquid	• rate	

Table 3. Specific Content Words

Specific Content Words – words that specify a particular thing (e.g., states of matter) or phenomena (e.g., law of Conservation of Mass). Describe the word and when possible make the connection to a Connecting Concept (e.g., States of matter are liquid, solid, and gas. Heat energy can change ice from a solid to water, which is a liquid.)		
• chemical change	• mixture	• products
• chemical properties	• particle motion	• reactants
• chemical reaction	• physical change	• states of matter
• law of conservation of mass	• physical properties	• visible property

Ideas to Support Vocabulary Learning

Table 4 includes ideas and examples for teaching vocabulary in ways to build conceptual understanding of the words.

Table 4. Ideas to Teach Vocabulary Effectively (Marzano, 2004)[1]

Ideas	Examples
Explain, describe, and/or give examples of the vocabulary word rather than formal definitions.	Provide a description and an example of matter, (e.g., "Matter is anything that takes up space and has mass. I am made of matter.").
Have students restate the vocabulary word in their own words. Take this	Have students state in their own words (verbally or using alternative and augmentative communication

Ideas	Examples
opportunity to help students connect new vocabulary, especially general vocabulary, to prior knowledge.	[AAC] system) what a mixture is and give an example as salt and water.
Have students represent vocabulary words in a variety of ways (e.g., pictures, symbols, graphic organizers, or models).	Have students complete a graphic organizer by sorting pictures as solids, liquids, or gases.
Provide multiple exposure to vocabulary words in a variety of ways. This does not suggest mass trials, but rather distributed trials in different ways or contexts. Reference http://projectlearnet.org/tutorials/learning_trials.html for information on learning trials.	• Incorporate vocabulary into daily activities such as determining if baking cookies, mixing sugar into tea, boiling water, shredding paper, etc., result in chemical or physical changes. • Read books or watch videos related to the vocabulary and concepts. o Watch a video that defines terms such as reflection (e.g., https://www.youtube.com/watch?v=cxsI0Av5624). o Read an online book on the states of matter (e.g., http://www.storyjumper.com/book/index/14684442/States-Of-Matter#) using a screen reader. • View vocabulary word definitions on matter and atoms online that are paired with pictures and read to the student (e.g., https://quizlet.com/141262578/atoms-and-matter-flash-cards/).
Ask students to discuss the vocabulary words with each other.	• Have students use their preferred mode of communication to share their favorite word and why. Adapt by placing the vocabulary word description on a voice output device and have the student share with a classmate. • Have students share with each other which are physical changes and chemical changes when cooking or completing a science experiment.
Play vocabulary word games with students.	• Have students use their communication system to describe a word and have peers guess what it is. • Have students match a description or representative picture to a word. • Have students play an online vocabulary review game (e.g., http://reviewgamezone.com/game.php?id=6995).
Have students watch a dramatization or have them act out the vocabulary term.	Act as a scientist explaining one of the science concepts to classmates or younger students.

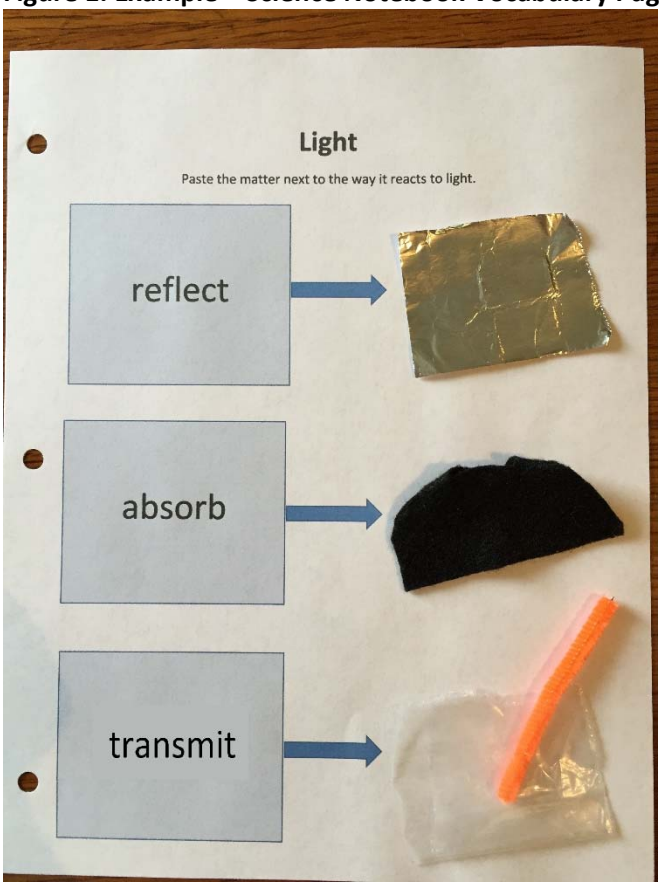
[1] Refer to Section VI, Universal Design for Learning (UDL) Suggestions for additional instructional strategies.

Vocabulary Example

Have students build an understanding of the terms reflect, absorb, and transmit by matching an object to the term (see Figure 1) and placing it in their science notebooks to review throughout the unit. Educators may need to support, modify, or adapt steps as needed for individual students. For example, provide larger objects and then take pictures for the notebook, create a digital science notebook that the student can access using assistive technology, provide the correct terminology on the student's AAC system, etc. Two National Center and State Collaborative (NCSC) resources are available and may prove helpful:

- Use systematic instruction as described in the NCSC Instructional Guide. https://wiki.ncscpartners.org
- Reference ideas in the NCSC Vocabulary and Acquisition Content Module. https://wiki.ncscpartners.org

Figure 1. Example – Science Notebook Vocabulary Page



Vocabulary Resources:

Vocabulary.com provides explanations of words using real-world examples. Once signed in, an educator can create word lists for students. http://www.vocabulary.com/

Text Project provides Word Pictures that are free for educators to use. It includes word pictures for core vocabulary and various content areas including science and social studies. This link will take you to the Word Pictures page where you can select the category of words you want to use. http://textproject.org/classroom-materials/textproject-word-pictures/

This site provides effective strategies for teaching science vocabulary. http://www.learnnc.org/lp/pages/7079

The Science Penguin site provides ideas to teach science vocabulary. The vocabulary demonstration activity uses real objects to teach vocabulary terms. http://thesciencepenguin.com/2013/12/science-solutions-vocabulary.html

This site provides a wide range of science graphic organizers, including some that are vocabulary specific. http://www.actedu.in/wp-content/uploads/2016/03/Science-Graphic-Organizers.pdf

Quizlet provides vocabulary terms paired with images and sound related to matter. Click on the accompanying Learn tab for an online quiz. https://quizlet.com/100754428/matter-flash-cards/

Section V

Overview of Units' Content

This section of the module contains additional content and references to support educators' understanding and instruction of the instructional units. The information reflects important content to address the AATs and to build students' knowledge, skills, and abilities; however, it is not exhaustive and should be expanded upon as appropriate.

Energy (elementary) – Various forms of energy are constantly being transformed into other types without any net loss of energy from the system: light reflection, absorption, or refraction.

Content:

- Light is a form of energy.
- Light travels in a straight line.
- Texture, color, and transparency of objects affect how light behaves when hitting the object.
- Light bouncing off an object is called reflection.
- All objects reflect some light.
- Light absorbed by an object or partially absorbed by a surface transforms into heat energy.
- Light can pass through transparent objects.
- Light can bend when it passes through transparent objects, and this is called refraction.

Matter (elementary) – physical properties of matter and factors that influence physical change in matter.

Content:

- Three states of matter are solid, liquid, and gas.
- Solids, liquids, and gases can be described by their physical properties.

- Physical properties can be observed or measured without changing the chemical nature of matter (e.g., solid, liquid, gas, freezing point, boiling point, etc.).
- Factors that influence the rate of water freezing or melting include temperature, size and shape, and conduction.
- Factors that influence the rate at which water evaporates include temperature, wind, exposed surface area, and humidity.

Matter (middle) – The composition and structure of matter is known, and it behaves according to principles that are generally understood: chemical reactions, visible properties of change, conservation of mass, atoms, and particle motion in states of matter.

Content:

- A chemical reaction happens when substances react together to form a new substance.
- Unknown substances can be identified by the characteristic manner in which they react chemically (e.g., baking soda and vinegar react differently than cornstarch and vinegar).
- Observations and measurements that show that a chemical change has occurred can include production of gas, creation of a solid, change in color, change in temperature, change in properties, etc.
- Matter can change forms.
- The mass of the reactants is equal to the mass of the products (Law of Conservation of Mass).
- All matter is made of tiny particles called atoms.
- Atoms cannot be created or destroyed.
- In chemical reactions, atoms are combined, separated, or rearranged.
- Atoms of different elements can combine to make molecules.
- Solids, liquids, and gases have different types of particle motion.
- Particles of solid matter are packed closely together and can only vibrate, resulting in matter that has a fixed shape.
- Particles in liquid matter have more room to move around than in a solid state, resulting in matter that takes the shape of its container and keeps the same volume.
- Particles in gas matter have a great amount of space to move around very quickly and spread out, resulting in matter that has no fixed shape or volume.

Unit Content Resources:

Light Reflection, Absorption, Refraction, and Transmission

- This site has an activity that demonstrates reflection and absorption. http://www.openschool.bc.ca/elementary/science4/html/bouncingLight.htm
- Better Lesson provides a lesson plan on creating models of light absorption, transmission, and reflection. http://betterlesson.com/lesson/633209/absorption-transmission-and-reflection-creating-models
- PBS Learning Media has a refraction of light demonstration. http://www.pbslearningmedia.org/resource/lsps07.sci.phys.energy.refractdemo/refraction-of-light-demonstration/

Matter

- Inquiry in Action has numerous investigative activities and background information for teachers on matter. http://www.inquiryinaction.org/pdf/InquiryinAction.pdf

Matter – Physical properties in matter

- This site describes physical changes and chemical changes. http://schools.bcsd.com/fremont/5th_sci_matter_physical_changes.htm
- This site provides a video on physical properties of the states of matter. https://www.youtube.com/watch?annotation_id=annotation_4109161969&feature=iv&src_vid=bMbmQzV-Ezs&v=21CR01rlmv4
- This site provides examples and properties of solids, liquids, and gases. http://www2.mcdaniel.edu/Graduate/TI/pages/LEWIS/matterweb.htm
- Soft Schools provides examples of physical properties. http://www.softschools.com/examples/science/physical_properties_examples/30/
- eSchool Today has information on the states and behavior of matter. http://eschooltoday.com/science/states-and-behaviour-of-matter/what-is-matter.html
- Chem4Kids has information on matter, states of matter, and chemical and physical changes of matter. http://www.chem4kids.com/files/matter_intro.html

Matter – Factors that influence physical change in matter

- Gizmos provides a lesson plan and an interactive simulation of water changing states. https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=661
- MnSTEP has an investigation on the factors that affect evaporation. http://serc.carleton.edu/sp/mnstep/activities/25448.html
- This link provides a lesson plan on factors that influence the rate at which water melts. https://stemteachersnowpdproject.wikispaces.com/file/view/5th+Grade+lesson+2.doc
- This site has a slide show with information on freezing, melting, and evaporation. http://www.slideshare.net/hiteshjuneja3572/freezing-melting-and-evaporation?qid=f86406fa-26a0-4ede-9fa2-342da6817847&v=&b=&from_search=1
- Innovative Technology in Science Inquiry has an interactive activity on melting ice. https://authoring.concord.org/activities/1076/single_page/29e7adb1-e333-49ec-9d11-e3723affef61

Matter – Chemical reaction and change

- Soft Schools provides a definition and examples of chemical properties. http://www.softschools.com/examples/science/chemical_properties_examples/35/
- The Download for Chapter 5 provides background information for the teacher on chemical changes. http://www.inquiryinaction.org/classroomactivities/activity.php?id=21
- This site provides activities to explore chemical changes. http://www.inquiryinaction.org/classroomactivities/activities_by_chapter.php?chapter=5&chapter_title=Chemical%20Change
- SAS has a lesson plan with an activity that differentiates between chemical and physical changes. http://pdesas.org/ContentWeb/Content/Content/6101/Lesson%20Plan
- SAS has a lesson plan with an activity that demonstrates chemical reactions. http://pdesas.org/ContentWeb/Content/Content/14041/Lesson%20Plan
- This site provides 10 examples of chemical reactions in everyday life and includes photos. http://chemistry.about.com/od/chemicalreactions/ss/10-Examples-of-Chemical-Reactions-in-Everyday-Life.htm
- Ducksters provides information on chemical reactions. http://www.ducksters.com/science/chemistry/chemical_reactions.php
- ACS provides lesson plans on chemical changes. http://www.middleschoolchemistry.com/lessonplans/chapter6

- The Concord Consortium provides an activity with an online data collector demonstrating chemical changes. https://concord.org/stem-resources/baggie-chemistry

Matter – Atoms, particle motion in states of matter, and conservation of matter

- This site simulates what happens to molecules of water, copper, and nitrogen when heated. http://www.miamisci.org/af/sln/phases/index.html
- This site has an activity to model the size of an atom. http://www.miamisci.org/af/sln/phantom/papercutting.html
- CK-12 provides a lesson plan on changes in matter and includes the law of conservation of matter. http://www.ck12.org/section/Changes-in-Matter-::of::-Introduction-to-Matter-::of::-CK-12-Physical-Science-For-Middle-School/
- These sites provide videos demonstrating the conservation of mass. https://www.youtube.com/watch?v=5o-UjU8l_3M and https://www.youtube.com/watch?v=774TbEUUM-A

Section VI

Universal Design for Learning (UDL) Suggestions

Three principles of UDL guide development of instruction, instructional materials, and assessments to provide access to learning to the widest range of students. Students with significant cognitive disabilities, especially students with visual and/or hearing impairments and students with complex communication needs, require additional scaffolds, adaptations, and modifications to access content and support learning. The three principles of UDL establish a framework for providing these. UDL provides guiding principles to create instructional materials and activities in a flexible manner to address the needs of different types of learners. Additionally, the flexibility allows for further individualization. Table 5 provides strategies and examples for the UDL Principle I, **Multiple Means of Representation**: presenting information in a variety of ways to address the needs of different types of learners. Table 6 provides strategies and examples for the UDL Principle II, **Multiple Means of Action and Expression**: providing a variety of ways for students to interact with the instructional materials and to demonstrate understanding. Table 7 provides strategies and examples for the UDL Principle III, **Multiple Means of Engagement**: providing a variety of ways to engage and motivate students to learn.

These strategies can assist all students in understanding the basic concepts. Some of the examples include adaptation ideas for students with vision, hearing, and/or physical limitations. Each example has a code to indicate when it includes specific adaptation ideas for these needs:

V = visually impaired (low vision, blind, or deaf-blind)
H = hearing impaired (deaf, hard of hearing, or deaf-blind)
P = physical disability (limited use of hands)

Table 5. Instructional strategy ideas using the UDL Principle: Multiple Means of Representation

Multiple Means of Representation	
Strategies	**Examples**
Introduce information through a multi-sensory approach (e.g., auditory, visual, tactile).	Have students go on a light hunt to find objects around the room that reflect, absorb, or transmit. Take photos of the objects and have students sort into categories of reflect, absorb, or transmit. Conduct experiments about: • light (e.g., http://www.perkinselearning.org/accessible-science/light-energy) **V** • chemical changes (e.g., Perkins School for the Blind has a hands-on lesson plan for observing chemical changes. http://www.perkinselearning.org/accessible-science/chemical-or-physical-change) **V** • chemical reactions (e.g., https://owlcation.com/stem/hands-on-experiments-to-learn-about-chemistry).
Model content through pictures, dramatization, videos, etc.	Demonstrate solids using common items (e.g., ice, school supplies, food), liquid items (e.g., water, oil, juice), and gas (e.g., cool mist vaporizer, water vapor from heated water). **P/V** Use pictures to show factors affecting the rate of evaporation (e.g., http://www.tncurriculumcenter.org/resource/1870/go). Use a roller ball mouse to hover over the pictures to get more information. **P** Watch video: • modeling chemical change (e.g., elephant toothpaste - https://www.youtube.com/watch?v=_J40MQEhOLY) or • relationship between states of matter and particle motion (e.g., https://www.brainpop.com/science/matterandchemistry/statesofmatter/) .
Present information using modified graphic organizers (e.g., simplified organizers with pictures) and models (e.g., tactile and pictures).	Use a KWHL to help students make connections between what they already **K**now, **W**hat they want to know, **H**ow they can find out, and finally, what they **L**earn. (slide show explaining the use of the KWHL chart and how it was made accessible for students with significant cognitive disabilities: http://www.cehd.umn.edu/nceo/teleconferences/tele14/CourtadeFlowers.pdf). **V/H/P** Have students complete a matrix showing the properties of three states of matter (e.g., https://www.brainpop.com/science/matterandchemistry/statesofmatter/activity/#=graphicOrganizer). Provide students picture choices and consider reducing the properties to observe.
Provide appropriate and accessible text on the content for students to listen to or read.	Paraphrase information from a textbook on large sticky notes. Place the sticky note over the original text, leaving the graphics. Write or type with a bold and plain font (e.g., Verdana, 18 pt. font) with good spacing between lines (e.g., 1.5 vs. single spacing). **V** Read online text about:

	• physical changes (http://www.ck12.org/physical-science/Physical-Change-in-Physical-Science/lesson/Physical-Change-MS-PS/?referrer=featured_content) or • chemical changes (e.g., http://www.ck12.org/physical-science/Chemical-Change-in-Physical-Science/lesson/Chemical-Change-MS-PS/?referrer=concept_details) using a screen reader. **V**
Teach information using songs.	• Teach through songs and videos: reflection/refraction (e.g., https://www.youtube.com/watch?v=F0otrjRR9YY).

Table 6. Instructional strategy ideas using the UDL Principle: Multiple Means of Action and Expression

Multiple Means of Action and Expression	
Strategies	**Examples**
Use assistive technology to allow the student to interact with the instructional materials and content.	When performing a chemical reaction experiment (e.g., https://www.youtube.com/watch?v=FZwHH7Sm4hI), have students create a table using pictures (printed or digital) to describe the physical properties and weight of the reactants and the physical properties and weight of the product(s) to demonstrate the mass does not change. Have students use assistive technology to interact with an online interactive animation (e.g., http://www.harcourtschool.com/activity/states_of_matter/molecules.swf). Set up an adaptive keyboard or a computer access switch to allow students to record data. **P**
Present instructional materials in a manner that provides access.	Place printed text and pictures on a slant board. **V/P** Provide students with science experiment directions that have been adapted using simple text and pictures. Use switch activated blender, mixer, etc., to complete investigation. **P** Provide a talking calculator, scales, thermometer, etc., for investigations. **V** Use wax sticks or glue to raise lines on graphs for investigations. **V**
Provide voice output devices for students to select an answer.	Record correct answers and distractors on a voice output multiple message switch or multiple voice output switches and have students answer questions using the switch. **P** Have students use three switches with generic labels (e.g., a, b, c; red, blue, green; or three different textures) to which they listen, and then select the correct answer. **V/P** Ask questions that can be answered with yes/no or with answer choices.
Provide simulation activities.	Have students observe a simulation of water changing states (e.g., http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_state.shtml), Have students observe a demonstration that shows that the pressure from atoms can inflate a balloon using an interactive model (e.g., https://concord.org/stem-resources/what-pressure).
Create a digital graphic organizer that allows drag and drop.	Have students watch an animation of states of matter (e.g., http://www.abpischools.org.uk/page/modules/solids-liquids-gases/slg2.cfm?coSiteNavigation_allTopic=1) using an adapted mouse or keyboard to maneuver through the animation. **P**

Table 7. Instructional strategy ideas using the UDL Principle: Multiple Means of Engagement

Multiple Means of Engagement	
Strategies	**Examples**
Provide a schedule and visual timer.	Provide personal schedules with tangible symbols. Have students select the next activity on the schedule and set the visual timer to indicate how long the student has before a break. Use a first/then schedule (e.g., http://www.autismclassroomresources.com/visual-schedule-series-first-then/).
Vary the challenge and amount of information presented at a time.	Begin with having students identify water, ice, and gas (in the form of steam). Then have students identify the states of matter. Finally, introduce factors that influence the change in states of matter.
Make connections to topics or activities that are motivating.	Make a textured book that includes content information and provides sensory feedback (e.g., https://tnt.asu.edu/sites/default/files/TextureBooks.pdf). Make connections to familiar and pleasing activities (e.g., light reflection/absorption/refraction with playground equipment, pool, etc.)
Allow choices as possible.	Allow students to choose whether to look at/listen to a book or watch a video about chemical reactions (e.g., https://www.youtube.com/watch?v=FofPjj7v414) during independent work time.
Provide opportunities to work collaboratively with peers.	Provide opportunities for students to work in a general education classroom with peers when learning about motion or have peer tutors come into the special education classroom to work conservation of matter investigations.
Teach student self-regulation skills.	Provide communication symbols to request a break or express feelings and model how to use them appropriately. Provide students with stress balls, finger fidgets, etc. Provide seating that offers sensory feedback (e.g., inflatable seat cushion, bean bag cushion, etc.).

UDL Resources

The National Center on Universal Design for Learning has a plethora of information on UDL along with examples and resources. www.udlcenter.org

The UDL Curriculum Toolkit provides two applications for science. http://udl-toolkit.cast.org/p/applications/l1

The Inquiry section of the document on this site has a chart providing variations on student roles in inquiry. http://www.inquiryinaction.org/pdf/InquiryinAction.pdf

Perkins School for the Blind provides physical science activities for students who are blind or have low vision. http://www.perkinselearning.org/accessible-science/activities/physical-science

This Perkins School for the Blind video, 20 minutes long, describes the techniques used to make science accessible for students who are blind and deaf-blind. https://www.youtube.com/watch?v=tpAejot1-Ec

Symbaloo is a free online tool that allows an educator to create bookmarks using icons. It is easy to create and allows an educator to provide students links to sources of information that can be used for specific instructional units.
www.symbaloo.com

This site provides a brief description of Symbaloo and multiple ways to use the online tool.
https://www.theedublogger.com/2014/04/09/11-ways-to-use-symbaloo-in-the-classroom/

Perkins School for the Blind provides information on using tangible symbols to increase communication, create personal schedules, and provide choices.
http://www.perkinselearning.org/videos/webcast/tangible-symbols

Section VII

Transference and Generalization of Concepts, Knowledge, and Skills

For learning to be meaningful for all students, including students with significant cognitive disabilities, it is important to intentionally make connections to future content, real-world application, and college and career readiness skills. For example, students can learn that the way they discover information through observation and investigation can also be used to problem solve daily living tasks. Additionally, the instruction of science concepts, knowledge, and skills may be the catalyst to developing other areas such as needed communication skills, reading/listening comprehension, mathematic skills, age-appropriate social skills, independent work behaviors, and skills in accessing support systems. Table 8 provides instructional ideas to help transfer and generalize concepts, knowledge, and skills and suggested opportunities to embed other skills into instruction.

Table 8. Transfer and Generalization Ideas

Area	Instruction	Opportunity to Embed Skills
Communication	While teaching vocabulary, make connections to real-life or future opportunities to use the words (e.g., use physical properties when describing something to someone).	Use the context of the content area instruction to increase language skills, work on articulation, or access alternative and augmentative communication (AAC) systems.
Reading and Listening Comprehension	Provide information through reading books and articles on science concepts while working on reading comprehension.	Provide practice on communication skills when students are answering questions or telling about an investigation.
Mathematics	Teach measuring and graphing during investigations.	Provide practice on number identification, and measuring temperature and weight/mass.

Age-Appropriate Social Skills	Make connections between the Connecting Concepts and real-life experiences showing how they can help students accept change (e.g., Understanding that some things change while some things stay the same may help a student in dealing with change more easily.).	Provide opportunities to work alongside same age peers to practice age-appropriate social skills and serve a vital role in the group.
Independent Work Behaviors	Encourage and reinforce independent completion of tasks to build independent work skills.	Use positive behavior supports to encourage and reinforce independent work skills. Use a self-monitoring sheet to encourage task completion.
Skills in Accessing Support Systems	Encourage students to ask appropriately for assistance from peers and adults when working on the content.	Use this time to have the student work on behavior and communication skills.

Section VIII

Tactile Maps and Graphics

The maps and graphics guidelines will help create tactile versions of instructional maps, diagrams, models, and timelines to use with students who are blind or deaf-blind. The tactile maps and graphics may be beneficial to other students as well. A tactile graphic is a representation of a graphic (e.g., picture, drawing, diagram, map, etc.) in a form that provides access through touch. It is not an exact copy of the graphic. The section provides basic guidance and links to more comprehensive resources.

Importance of Tactile Maps and Graphics

It is important to provide tactile graphics for young readers (BANA, 2011). It helps students understand and gain information when presented with science and social studies concepts, knowledge, and skills. Science instruction often presents diagrams (e.g., water cycle) and two-dimensional models of living and nonliving things (e.g., model of cell) to teach the related concepts. Social studies instruction often uses maps and timelines to illustrate where and when people existed and events occurred. The following guidance includes information to build upon when creating tactile graphics.

Tactile Graphic Guidance

1. **Determine need for graphic:** When encountering graphics in instructional materials, determine if the graphic is essential to understanding the concept. The Braille Authority of North America (2010) provides a decision tree to help in this determination. It can be accessed online at http://www.brailleauthority.org/tg/web-manual/index.html by selecting “Unit 1 Criteria for Including a Tactile Graphic.”
2. **Consult with the local educator trained to work with students with visual impairments.**
3. **Determine the essential information in the graphic.** Read the surrounding information and the caption to determine which information in the graphic to exclude. For example, a map to illustrate

location of key countries would not need state lines and capital cities and may not need all of the surrounding countries.

4. **Reduce unnecessary detail in the graphic.** Identify details that are not necessary for interpreting the information in the graphic. For example, a model of the water cycle may show crevices on the mountains, leaves on a tree, and waves in an ocean. Eliminate unnecessary details, as they are difficult to interpret tactilely.
5. **Remove frames or image outlines if they serve no purpose.** Ensure that all lines are necessary (e.g., line that indicates a body of water), and remove any that are not.
6. **Modify the size of the graphic.** Modify the graphic as needed to reduce clutter and allow a blank space between adjacent textures. Additionally, consider the size of the student's hand.
7. **Use solid shapes as feasible.** When solid shapes do not clearly represent the information, use clear solid lines.
8. **Systematically teach exploration and interpretation of tactile graphics.** Systematic instruction and repetition are important when teaching a student to understand a tactile graphic. Pairing the tactile graphic with a 3-dimensional object may help (e.g., pair a raised line drawing of a pencil, an example of goods, with a pencil).

Specific Graphic Type Guidance

Following is information for specific types of graphics that may support instruction in science and social studies.

Graphic Organizers/Concept Maps

- It is best to present information to compare or make connections in a tactile graphic. A tactile graphic presents the information in a spatial display and aids in comparison better than a list.

Diagrams/Models

- Limit the number of areas, lines, and labels. Having more than five makes interpretation difficult.
- Consider pairing a tactile graphic with a 3-dimensional model.

Timelines

- Present timelines in the same direction every time (i.e., horizontal or vertical).

Maps

- Distinguish water from land using a consistent background texture for the water.
- Align the direction of the compass rose arrows with the lines of longitude and latitude on the map.

Creating Tactile Graphics

Following are some ways to create tactile graphics. Additional information can be found at www.tactilegraphics.org.

Commercial products:

- Capsule paper or swell paper – print
- Thermoform

Textured shapes can be made from:

- Sticky back textured papers found at craft stores
- Corrugated cardboard

- Fabric with texture (e.g., corduroy, denim)
- Silk leaves
- Cork
- Felt
- Vinyl
- Mesh tape (used for drywall)
- Sandpaper

Raised lines can be made from:

- Glue (best not to use water-based glue)
- Wax pipe cleaners

Resources

Creating Tactile Graphics, created by the High Tech Center Training Unit, provides basic principles of tactile graphics, characteristics of good tactile graphics, the planning process, guidelines for designs, and more. http://www.htctu.net/trainings/manuals/alt/Tactile_Graphics.pdf

The Texas School for the Blind and Visually Impaired provided basic principles for Preparing Tactile Graphics, element arrangement on a tactile graphic, resources for preparing quality graphics, etc. http://www.tsbvi.edu/graphics-items/1465-basic-principles-for-preparing-tactile-graphics

Perkins School for the Blind has short videos that explain the importance of tactile graphics and information on spatial relationships and graphic literacy, moving from models to graphics, and strategies for reading tactile graphics. http://www.perkinselearning.org/videos/webcast/teaching-tactile-graphics

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